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CHANGES IN SENSORY CHARACTERISTICS, TEXTURE AND ORGANIC VOLATILES OF IRRADIATED AND NONIRRADIATED PORK CHOPS

Irradiated Food Products Group
Radiation Preservation of Food Division

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UNITED STATES ARMY
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Pork Chops prepared from fresh longissimus muscle pumped with brine solutions containing varied concentrations of sodium chloride and sodium tripolyphosphate (TPP) were tested as non-irradiated or irradiated (5.1-6.1 Mrad at −30°C (±10°C) items by technological and consumer panels for the sensory characteristics and preference ratings. Texture determinations were made using an Allo-Kramer Shear device. Total organic volatiles were determined using a steam distillation and permanganate oxidation method. The addition of 0.75% NaCl and 0.3% or over

plus or minus

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20. Abstract (cont'd)

0.5% TPP significantly reduced the cooking losses in the pork chops and increased the overall acceptances. Texture was significantly improved by the addition of NaCl and TPP. NaCl without the TPP addition was less effective. The addition of the NaCl and TPP did not increase the total organic volatiles. The addition of 0.3% TPP was sufficient when used in combination with 0.75% NaCl.

SUMMARY

The cooking losses in pork chops were reduced by 9% when 0.75% NaCl and 0.3 or 0.5% TPP were added to the chops. The acceptance of the irradiated and nonirradiated pork chops was significantly increased by the addition of NaCl and TPP. Salt alone did not significantly increase the acceptance when compared to samples without the additives.

Texture ratings showed significant improvements by the addition of 0.3 or 0.5% TPP, along with 0.75% NaCl, in both the technological panel scores and shear press determination. The addition of 0.75% NaCl without phosphate did not result in a significant improvement in the quality of pork chops.

There were no increases in the total organic volatiles due to the additions of NaCl and TPP.

PREFACE

These investigations were conducted to determine the effects of pumping boneless pork loins with a solution containing sodium chloride and sodium tripolyphosphate on the sensory characteristics of grilled pork chops. Measurements of texture were determined using an Allo-Kramer shear press.

Results from these studies showed that acceptable irradiated pork chops with improved flavor and texture can be produced by injecting pork loins with a solution to bring the concentration of the salt and tripolyphosphate to 0.75% and 0.3% respectively.

These studies were undertaken as a research project of the Irradiated Foods Product Group, Radiation Preservation of Foods Division, Food Engineering Laboratory, under Project 1T762724AH99.

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INTRODUCTION

The acceptance and storage stability of irradiated pork chops without any additives have been reported by several investigators; Cain[1] et al. (1958), Gernon[2] et al. (1961), and Heiligman[3] (1965).

Cain et al. (reference 1) reported no significant changes in the flavor of precooked, irradiated pork chops up to 250 days storage at 21°C. Fresh, noncooked, irradiated pork chops had extensive degradation of the flavor and textural characteristics due to the proteolytic enzyme activity and were unacceptable after 250 days storage at 21°C. Gernon et al. (reference 2) found cooked pork chops acceptable after 25 months storage at 21°C, but preference ratings were decreased at 38°C storage. Heiligman (reference 3) found that enzyme-inactivated irradiated pork chops were rated approximately the same after 18 to 24 months storage at 21°C as they did prior to storage. Preference ratings decreased after 9 to 12 months storage at 38°C. Shults[4] et al. (1976) reported the improvements in texture and flavor characteristics of formed irradiated and nonirradiated, enzyme-inactivated pork rolls with the addition of sodium chloride (0.75%) and sodium tripolyphosphate (0.3%). The effects of the salt and condensed phosphates in pork muscle were reported by Shults and Wierbicki[5] (1974) and significant improvements were found in the water-holding capacity.

[1] Cain, R. F., A. F. Anglemier, L. A. Suther, F. R. Bautista and R. H. Thompson 1958. Acceptability of fresh and precooked radiated meats. Fd. Res. 23: 603.

[2] Gernon, G. D. Jr., F. J. Kraus and M. P. Drake 1961. Effect of active carbon on the storage stability of irradiated meats. Food Tech. 15: 354.

[3] Heiligman, F. 1965. Storage stability of irradiated meats. Food Tech. 19: 114.

[4] Shults, G. W. and E. Wierbicki 1974. Effects of condensed phosphates on the pH, water-holding capacity and meat swelling properties of pork muscle. TR-74-22-FL, U.S. Army Natick Laboratories.

[5] Shults, G. W., J. J. Howker and E. Wierbicki 1976. Effect of salt and condensed phosphates on texture, organic volatiles and sensory characteristics of irradiated pork rolls. J. of Fd. Sci. (in press).

This research task was initiated to determine the improvements, if any, in irradiated pork chops prepared with sodium chloride and sodium tripolyphosphate prior to enzyme inactivation, packaging, and irradiation. The effects of the additives were determined using organleptic, chemical, and physical testing procedures for both the irradiated and nonirradiated samples.

MATERIALS AND METHODS

Boneless pork loins, longissimus muscle, were used for these experiments. The external fat was removed and the loin randomly separated into four groups. The loins from each group were pumped with a brine to 10% added weight with an injecto pump, 414 kPa. The solutions contained sodium chloride (NaCl), 0% or 7.5%, and sodium tripolyphosphate (TPP), 0%, 3.0%, or 5.0%. After pumping, the concentrations of the additives in the pork loins were 0% NaCl, 0% TPP; 0.75% NaCl, 0% TPP; 0.75% NaCl, 0.3% TPP; and 0.75% NaCl, 0.5% TPP for the four groups.

The loins were held 12 hours at +2°C and then sliced into 13-mm thick chops, 80 to 100 grams each. The chops were broiled at 225°C in an electric broiler to an internal temperature of 71°C to 77°C.

After broiling, the chops were cooled to 2°C to 5°C and packed in 404 x 309 size cans under 6.5 kPa ± 1 kPa of pressure. The sealed cans were frozen to -40°C ± 5°C prior to irradiation processing.

Irradiation of the product was carried out in the Cobalt-60 source at the U.S. Army Natick Research and Development Command. All samples received a gamma-irradiation dose in the range of 5.1 to 6.1 megarads. Temperature during irradiation was controlled with liquid nitrogen at -30°C ± 10°C. Dose rate was 8.79 x 10^4 rads per second. After irradiation, the samples were stored at + 21°C for 0 and 30 days. Frozen nonirradiated samples were stored at -19°C.

Sensory Evaluation After Toxin Testing

Samples were subjected to trained technological panels of 10 to 12 panelists who evaluated them for the sensory characteristics: odor, flavor, color, and texture. The sensory characteristics ratings were scored using an intensity scale of 1 (extremely poor) to 9 (excellent).

Preference ratings were obtained using both the trained technological panels of 8 to 10 panelists and consumer-type panels of 32 to 36. Indications of preference were made on a hedonic scale of 1 to 9 reported by Peryam and Pilgrim[6] et al. (1957) with 1 being "disliked extremely" and 9 meaning "like extremely". A rating of 5, "neither like nor dislike", was considered a threshold for the acceptability of the product.

[6]Peryam, D. R. and F. J. Pilgrim 1957. Hedonic scale method for measuring preferences. Food Tech. 11 (9), supplement: 9-14.

Statistical analyses were performed on all data to determine significant differences between the samples. Significance was determined at the five percent level by using an analysis of variance and multiple range test reported by Steel and Torrie[7] et al. (1960).

Texture Determination (Shear Press)

Pork chop tenderness was measured using an Allo-Kramer Shear Press modified to function as a penetrometer by substituting an apparatus containing five 3.2-mm-diameter drill rods, semi-blunt, having 1.5-mm-diameter land and 6.7/25.4-mm taper in place of the standard shear compression cell and shearing blades. Readings are expressed in Newtons reported by Hinnergardt and Tuomy[8] et al. (1970). Three readins were taken per chop, 12 replicates for each variable.

Total Organic Reducing Volatiles

The total organic volatiles were determined using steam distillation of organic volatiles into a permanganate solution, oxidation of the organic volatiles by the oxygen from the permanganate solution (first in alkaline and then in acid medium) and determination of the residual, unused permanganate. A 50-g sample of pork was added to 350 ml of distilled water and homogenized for 90 seconds. The homogenate was placed in a 200-ml flask with 5 ml picric acid and glass beads. Seventy ml were distilled into a 500-ml erlenmeyer flask containing 50 ml of 0.05 N $KMn\ O_4$ and 5 ml of 0.1 N NaOH. The receiver flask was refluxed for 10 minutes and 10 ml of dilute of H_2SO_4 (1 to 3) added to the solution. The solution was refluxed for an additional 25 minutes. Following the reflux, 25 ml of 0.1 N $(NH_4)_2C_2O_4.H_2O$ were added, and the solution was back titrated with 0.05 N $KMNO_4$. This procedure is a quantitative determination and the results are expressed in milliequivalents of oxygen consumed by the volatiles obtained from 100 grams of pork. Calculations are as follows:

$$\text{Milliequivalents } O_2 = \frac{\text{ml K Mn } O_4 \times \text{N K MN } O_4}{\text{Sample Weight (g)}}$$

[7]Steel, R. G. and J. H. Torrie 1960. Principles and Procedures of Statistics. 1st Ed. Pg 110, McGraw-Hill.

[8]Hinnergardt, L. and J. Tuomy 1970. A penetrometer test to measure meat tenderness. J. of Fd. Sci. 35: 312.

RESULTS AND DISCUSSION

The percent of cooking losses for each set of samples was determined by the difference between raw weight and cooked weight of each sample. Nineteen kilograms of pork chops were cooked for each of the four samples. Results in Table 1 show an 8 to 9% reduction in cooking loss when 0.3 or 0.5% TPP was added. Salt addition (0.75%) alone did not result in any appreciable reduction. This confirms earlier results obtained on irradiated pork rolls reported by Shults and Wierbicki et al. (reference 5). However, the reduction in the cooking losses in pork chops was not as great as found in the pork rolls due to differences in the cooking methods.

Effect of Phosphate Addition

Differences in the ratings for the sensory characteristics and preference of nonirradiated pork chops prepared with three levels of TPP (0, 0.3 and 0.5%) and 0.75% NaCl are shown in Table 2. At 0 days storage, the samples with 0.3% TPP and 0.5% TPP were significantly different from the samples without NaCl and TPP for texture and preference ratings. At 30 days storage, no significant differences were found between the samples for the sensory characteristics and preference ratings.

The ratings for the irradiated samples listed in Table 3 show that the samples with 0.75% NaCl and 0.3 or 0.5% TPP were significantly superior to the sample without the NaCl and TPP and the sample with the 0.75% NaCl in preference and flavor at the 0 days storage evaluation. At 30 days storage, the samples with 0.3 and 0.5% TPP were rated higher for flavor, texture, and preference, but the differences were not statistically significant. The samples without the NaCl and TPP were rated significantly lower for odor than the other samples.

Table 4 lists the results of the evaluation of the irradiated samples compared to a nonirradiated frozen control sample with 0.75% NaCl and 0.3% TPP. At 0 days storage the nonirradiated control and the samples with 0.3% and 0.5% TPP were significantly preferred to the sample without NaCl and TPP. The sample with 0.75% salt was also rated significantly different from the nonirradiated control in preference ratings. The sample without the NaCl and TPP was rated significantly lower than the other samples for texture. Results of the 30 days evaluation show that the sample without NaCl and TPP was rated significantly different from the other samples for flavor, texture, and preference.

Consumer panel preference results for the samples stored for 30 days are shown in Table 5. For the irradiated samples, the 0.3 and 0.5% TPP samples were significantly preferred to the samples without NaCl and TPP and with 0.75% NaCl. Ratings for the

nonirradiated samples show the samples without NaCl and TPP significantly were less preferred than the other samples. Ratings from the evaluation of the irradiated samples compared with a nonirradiated frozen control with 0.75% NaCl and 0.3% TPP show the control and irradiated sample with 0.3% TPP significantly preferred to the samples without the TPP.

It can be concluded from the results of these organoleptic evaluations that TPP and NaCl are essential for producing a high quality, irradiated pork chop. Differences in pork chops with 0.3% and 0.5% TPP were minimal. A concentration of 0.3% TPP can be considered optimal for producing irradiated pork chops. Sodium chloride alone is not sufficient to produce a high quality product.

Texture Determination (Shear Press)

The physical evaluations for texture of the pork chops were performed with a shear press device after 30 days storage. The shear press results in Table 6 show that the samples with 0.3 and 0.5% TPP, both the irradiated and frozen nonirradiated control, are significantly more tender than the samples without TPP. The samples with 0.75% NaCl were also more tender than the sample without NaCl and TPP. Differences were found between the nonirradiated and irradiated samples containing 0.75% NaCl and those containing 0.75% NaCl and 0.3% TPP.

These results emphasize the importance of the addition of NaCl and TPP to irradiated pork chops for the production of a higher quality item. The shear press results confirm the data obtained from the technological panels.

Total Organic Volatile Concentration

Table 7 gives the results for the total organic volatiles of the irradiated and nonirradiated samples at 0 and 30 days storage. The nonirradiated sample shows less volatile production than the irradiated samples. However, no significant effect on the volatiles production was caused by the additives, NaCl and TPP.

REFERENCES

1. Cain, R. F., A. F. Anglemier, L. A. Suther, F. R. Bautista and R. H. Thompson 1958. Acceptability of fresh and precooked radiated meats. Fd. Res. 23: 603.

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6. Peryam, D. R. and F. J. Pilgrim 1957. Hedonic scale method for measuring preferences. Food Tech. 11 (9), supplement: 9-14.

7. Steel, R. G. and J. H. Torrie 1960. Principles and Procedures of Statistics. 1st Ed. Pg 110, McGraw-Hill.

8. Hinnergardt, L. and J. Tuomy 1970. A penetrometer test to measure meat tenderness. J. of Fd. Sci. 35: 312.

TABLE 1

Cooking losses of pork chops

Sample		% Cooking Loss
0% NaCl	0% TPP	34
0.75% NaCl	0% TPP	32
0.75% NaCl	0.3% TPP	26
0.75% NaCl	0.5% TPP	25

Average of 19 kilograms of pork chops per sample.

TABLE 2

Effects of NaCl and TPP on the sensory characteristics and preference ratings of nonirradiated pork chops

0 Days Storage

Samples		Sensory Characteristics				
%NaCl	% TPP	Color	Odor	Flavor	Texture	Preference
0	0	7.2	6.4	6.4	5.6	5.9
0.75	0	7.3	7.0	7.0	6.9	6.9
0.75	0.3	7.4	7.4	7.2	7.3[1]	7.1[1]
0.75	0.5	7.5	7.3	7.3	7.3[1]	7.0[1]

30 Days Storage

0	0	7.4	7.0	6.9	6.3	6.9
0.75	0	7.4	7.0	7.0	6.4	7.0
0.75	0.3	7.0	6.4	6.7	6.6	6.9
0.75	0.5	7.4	7.1	7.3	6.5	7.2

12 panelists per test

[1] Significantly different from the sample with no additives ($P<0.05$)

TABLE 3

Effect of NaCl and TPP on the sensory characteristics and preference ratings of irradiated pork chops

0 Days Storage

Samples		Sensory Characteristics				
% NaCl	% TPP	Color	Odor	Flavor	Texture	Preference
0	0	6.1	5.2	4.4	6.0	5.0
0.75	0	6.3	5.3	4.5	6.1	5.1
0.75	0.3	6.5	6.9[a]	6.0[a]	6.6	6.5[a]
0.75	0.5	6.2	6.0	6.1[a]	6.2	6.2[a]

30 Days Storage

0	0	7.4	6.4[b]	6.2	6.5	6.4
0.75	0	6.6	7.2	6.4	6.0	6.2
0.75	0.3	7.5	7.2	6.8	7.3	6.8
0.75	0.5	7.2	7.2	6.8	6.9	6.7

10 panelists per test

Irradiation: 5.1 to 6.1 Mrad at -30°±10°C

[a]Significantly different from the samples with no additives and 0.75% NaCl ($P<0.05$)

[b]Significantly different from the other samples ($P<0.05$)

TABLE 4

Effects of NaCl and TPP on the sensory characteristics and preference ratings of irradiated *vs* nonirradiated pork chops

0 Days Storage

Samples			Sensory Characteristics				
% NaCl	% TPP	Dose	Color	Odor	Flavor	Texture	Preference
0	0	5.1 Mrad	5.7[a]	4.9	4.8	5.4[a]	5.1
0.75	0	5.1 Mrad	6.1	5.9	5.4	6.4	5.6[a]
0.75	0.3	5.1 Mrad	5.6[a]	6.4[b]	5.4	5.8	6.3[b]
0.75	0.5	5.1 Mrad	6.6	6.4[b]	5.5	6.1	6.3[b]
0.75	0.3	0 Mrad	6.9	6.4[b]	6.8[c]	6.1	7.1[b]
(Frozen Control)							

30 Days Storage

0	0	5.1 Mrad	6.7	7.1	5.7[a]	5.5[a]	5.8[a]
0.75	0	5.1 Mrad	6.7	6.6	6.1	6.3	6.2
0.75	0.3	5.1 Mrad	6.9	7.0	5.8[a]	6.5	6.1
0.75	0.5	5.1 Mrad	7.3	6.9	6.7	6.5	6.5
0.75	0.3	0 Mrad	7.5	7.7	7.6	7.3	7.3
(Frozen Control)							

10 panelists per test

[a]Significantly different from the non-irradiated sample ($P<0.05$)

[b]Significantly different from the sample with no additives ($P<0.05$)

[c]Significantly different from the other samples ($P<0.05$)

TABLE 5

Consumer panel preference ratings for irradiated and nonirradiated pork chops

Samples	Irradiated	Nonirradiated	Irradiated vs. Nonirradiated
0%	5.3	5.8	5.3
0% TPP			
0.75% NaCl	5.9	6.8[a]	5.3
0% TPP			
0.75% NaCl	6.4[b]	6.6[a]	6.3[b]
0.3% TPP			
0.75% NaCl	6.4[b]	6.5[a]	5.9
0.5% TPP			
0.75% NaCl	–	–	6.5[b]
0.3% TPP			
Frozen Control			

32 to 35 panelists per test.

Irradiation: 5.1 to 6.1 Mrads, -30°C±10°C

[a]Significantly different from the sample with no additives ($P<0.05$)

[b]Significantly different from the samples with no additives and 0.75% salt ($P<0.05$)

TABLE 6

Shear press values for pork chops with various additions of NaCl and TPP

Samples		Shear Value*	
% NaCl	% TPP	Irradiated	Nonirradiated
0	0	44.1	52.0[c]
0.75	0	37.3[d]	41.1[ac]
0.75	0.3	27.4[b]	33.3[bc]
0.75	0.5	32.4[b]	32.4[b]

*Shear Force in Newtons required to penetrate 13 mm thick pork chop

[a]Significantly different from the sample with no additives ($P<0.05$)

[b]Significantly different from the samples without TPP ($P<0.05$)

[c]Significance found between irradiated and frozen control ($P<0.05$) samples

TABLE 7

Effects of NaCl and TPP on the total organic volatiles of pork chops

Additives		Samples: Nonirradiated pH	Nonirradiated ORV*	Irradiated 0 days storage pH	Irradiated 0 days storage ORV*	Irradiated 30 days storage pH	Irradiated 30 days storage ORV*
0% NaCl	0% TPP	5.8	0.87	5.5	1.14	5.5	1.09
0.75% NaCl	0% TPP	5.8	1.21	5.7	0.94	5.7	1.26
0.75% NaCl	0.3% TPP	5.9	0.65	5.9	1.18	6.0	1.27
0.75% NaCl	0.5% TPP	6.0	1.15	6.3	1.46	5.9	1.27

Irradiation: 5.1 – 6.1 Mrad at -30°C ± 10°C

*Organic reducing volatiles, milliequivalents oxygen per 100 g meat.